Capture-Recapture Lesson Plan (Grades 6-8)

Objectives:
- Recognize equivalent ratios
- Determine good and poor estimates
- Solve proportions to estimate population size

Materials*:
- Estimating Population Size Activity Sheet
- Black Marker
- 64 Flying Squirrels per group (can be found under sources)
- 32 Squirrels per group (can be found under sources)
- 2 Sheets of Printer Paper per group
- Ziploc bag or cup for holding paper cut-outs
- Circle (Cut Out) per group (can be found under sources)
- Top to Printer Paper Box

*See "Alternate Materials" at the end of lesson plan for additional ideas for manipulatives.

Before Class Preparation by Teacher:
(For Activity 1) Before class starts, put about 30 post-it notes on the walls around the classroom. This is to simulate a population in its natural habitat. It is a good idea to put up enough post-it notes so that it is a little difficult for students to count without losing track, but not so many that this activity takes a long time. Also, in order for the students to understand the difficulty of just counting the population by sight, make sure to hide 6-8 post-it notes in areas students may not think to look, for instance, under a couple of student's' desks or in a hidden corner. It is important that the students do not find all the post-it notes on the first look search.

(For Activity 2) Before beginning this activity, for each group prepare 64 flying cartoon squirrels, 32 regular squirrels, and two sheets of printer paper cut up into squares of almost equal sizes. The flying squirrels will simulate actual flying squirrels in their natural habitat, and the cut up blank sheets of paper represent vegetation in the natural habitat that would block a field ecologist's field of vision to make counting difficult. The regular squirrels represent another species in the habitat that is not endangered, that might end up in the trap with the species of interest. Put the cut out flying squirrels, regular squirrels and vegetation squares into a ziplock bag or cup. It is important that the students do not know the number of flying squirrels at the beginning of the activity. The inside of the printer paper box top needs to be separated into 9

equal rectangular sampling regions. Then, the annulus needs to be cut with a hole in the middle to be the trap. This circle will become the trap. Finally, there needs to be a worksheet for every member of the group.

Instruction Plan:

Introduction:

Begin class talking about endangered species. In Tennessee, there are four endangered bird species, twenty endangered fish species, three endangered mammal species, three endangered snail species, and thirty-nine endangered mussel species. With endangered species, field ecologists want to keep an accurate account of how many are left in a population. Discuss with the class: "What do you think some of the problems are with keeping accurate data on endangered species?" One of the mammals endangered in Tennessee is the Carolina Northern Flying Squirrel. Ask the class, "What do you know about this animal? What do you think are some of the specific problems field ecologists have with keeping accurate population data on this mammal?" Tell the students today they are going to try different methods field ecologists might use to study animal populations. The students will focus on the flying squirrel.

Activity 1: How many can you count?

Once class begins, ask for two volunteers. Let the students know that there is a wild population of flying squirrels (post-it notes) in the classroom. It is up to the two volunteers to count all of the flying squirrels with help from their classmates in their seats. They should each start in a different spot and count independently of each other, but with help from their classmates. After the two volunteers count all the post-it notes they can see, ask the two students for their totals and record them on the board. If the totals are different, you can discuss why that might have happened. Ask the whole class if they agree with the total (s). After they agree, tell students that they forgot that animals hide! Tell students to look under their desks or anywhere else that you hid the post-it notes. When all the post-it notes have been located, tell the students this is a problem many field ecologists go through when trying to find all the animals in a population, because animals like to hide. Tell students to imagine how much more difficult it would be if the animals were also moving around.

Activity 2: Estimating Population Size:

To begin this activity, tell students they will be field ecologists today running through a simulation to count the flying squirrels are in their habitat. First, students need to take the bag of paper cut-outs and spread them throughout the regions. Make sure the students have an approximately even distribution of the cut-outs throughout the habitat. Explain that the students

will be using two different methods to estimate the population size. Their habitat has been divided into equal portions, called sampling regions, which will help ensure that the sampling is random and unbiased.

For the first method, students will count the flying squirrels that are trapped in sample regions, and then estimate the total number of flying squirrels in the entire habitat. In order to begin, the the teacher should choose four numbers at random to correspond with the regions the students should sample. The teacher writes these region numbers on the board. Students then record the the region numbers in the left-side of the table. Then, students trap in those regions. Demonstrate "trapping" for the students. Have them place their trap down somewhere in the selected region. Then, they should scoop up all of the squirrels (flying and regular) and vegetation that are within the trap's boundary. Students then separate, count and record the flying squirrels that they have scooped out. Then, this is repeated in the next region. Tell students to make sure they do not put their trapped squirrels and vegetation back into the habitat until they are done counting in all four selected regions. Students then follow the directions on the worksheet to finish the estimate of the flying squirrel population, and have each group complete the questions. After the students have completed the first method, record on the board each group's total and discuss the two questions. Point out and discuss differences in the estimates that were found by different groups.

For the second method, the students will be using a common field ecology practice of mark and recapture. Again, four random region numbers need to be selected by the teacher. The students will again trap in the four regions and separate the flying squirrels from the vegetation and the regular squirrels. Make sure they do not reintroduce the materials back into the habitat until they have recorded all of the flying squirrels from the four regions. After they have recorded the amount of flying squirrels they have captured, the students need to mark the squirrels (only the flying ones!) by using a marker and placing a dot on their captured animals. Once they are done marking, they need to reintroduce the material into the habitat. Again, four random region numbers need to be selected to trap. The students need to trap and separate the flying squirrels from the other material. Then, the students need to separate them into marked and unmarked and record the data. The students will use equivalent ratios to make the flying squirrel population estimate.

After the groups have had enough time to discuss and complete their calculations, they need to report their estimates from method 2. After the teacher records the data on the board, the groups can complete the questions. Once they have been completed, the class may come together for discussion of the questions. At the end of class, you can let the students know that there were 64 flying squirrels in their habitats. Or you can keep it a secret and make the point that in the field, there is no way to ever really know! You must instead trust your mathematical modeling.

Assessment and Extension:

Assessment:
Ask students to solve a comparable question:
Jake wants to know how many students from his school were at the soccer match and saw him score a goal. He knows that there are 850 students at his school. At lunch, he randomly asked 35 students if they had seen the game, and 3 of them said that they had.
- How can you use this information to estimate how many student from his school were at the game? Estimate how many students were there, and show your work.
- How confident are you that your estimate is close to the actual number of students who were at the game?
- What suggestions do you have for Jake to make sure that the estimate is close to the actual number of students that saw the game? [Take a few more samples to see what the range of estimates is or take a larger sample and compare the results.]

Extensions:
1. What if one field ecologist marks the birds with a blue label, and another field ecologist uses a red label. What effect does this have on the way they recapture and use the data? Simulate this using a second marker to mark the beans with another colored pen.
2. Have students write up different scenarios where capture-recapture would be applicable.
3. If the students have time to count the total number of flying squirrels, ask them to calculate the percent of error between their guessed population size and actual population size.

TN Math Standards:

6th Grade:
Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

7th Grade:
Use proportional relationships to solve multistep ratio and percent problems.

Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

Use data from a random sample to draw inferences about the population with an unknown characteristics of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

Sources:
Silver, Z. 2016. Capture-Recapture. Classroom Resources: Illuminations, National Council of Teachers of Mathematics.

Adapted by Virginia Parkman, Kelly Sturner, and Suzanne Lenhart

Thanks to Elizabeth Hobson for help in shaping this activity.
Flying Squirrel Picture: http://www.clipartbest.com/clipart-McLL65b7i
Squirrel Picture: http://clipartion.com/free-clipart-9437/

Alternative Materials:

- "Underbed" plastic boxes, 1 per group (~$9 each-reuseable) - replaces box top and simulates the habitat area
- Paper taped to the bottom of boxes marking out 10-16 equal rectangular sections (regions) - each must be a little larger than the area of the trap.
- Great Northern Beans, 2 lbs (or ~ ⅓ cup of beans per group) (~$3 total) - replaces cut out flying squirrels
- To mark beans -- use Sharpie markers rather than another kind that might rub off, 1 per group
- Pine bedding, ½ cup per group (~$3 total) - replaces the blank cut up printer paper and regular squirrels and simulates vegetation and other cover in the squirrel habitat
- Plastic cups, 18 oz, with the bottoms cut away such that the rims and about 1 ½ inches of the cup wall remain, 1 per group (~$3 total, reuseable) - replaces the cut out circle and simulates the squirrel trap.
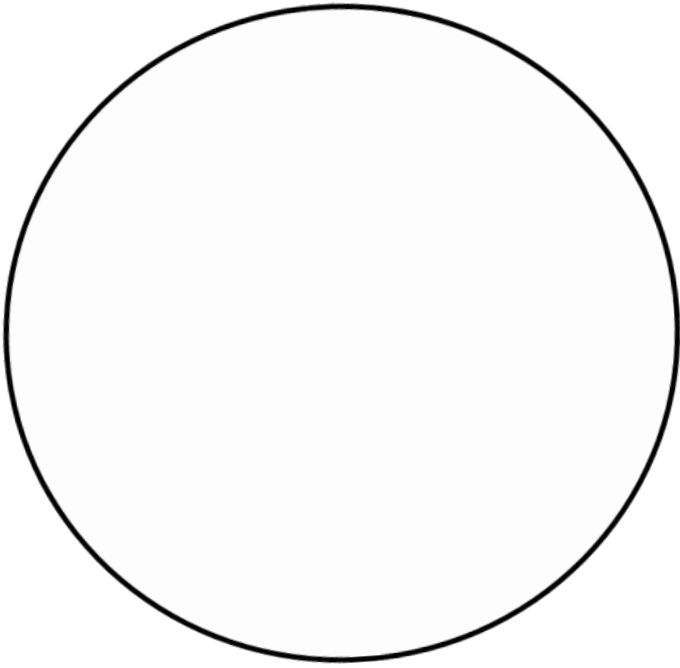
Estimating population sizes: How many flying squirrels are in your area?

Imagine you are an ecologist who studies flying squirrels, an endangered species in Tennessee. You need to know how many flying squirrels are left in their habitat. How will you count them without having to trap or capture every single one? What is the best way to estimate their population size? Let's do a simulation to find out!

Method 1: Count the flying squirrels (beans) that you trap in sample regions, then estimate the total number of flying squirrels in the entire habitat.

Directions: Your teacher will randomly choose 4 regions in the habitat where you will capture flying squirrels (beans). In the table provided, record the four sample regions announced by your teacher. Then, use your trap to capture once in each region, finding the number of flying squirrels in your captured sample. Do not reintroduce the flying squirrels to the habitat until you have used your trap once in each region and counted all of the captured flying squirrels.

Sample Region	# of Flying Squirrels
1st:	
2nd:	
3rd:	
4th:	
Total =	
Average =	

You are sampling from four regions. What is the total number of regions in your habitat? _____

Average # of flying squirrels   total # of   Estimated total #
    per sample region   X   regions   =   of flying squirrels

_____   X   _____   =   _____

Question 1: Do you think the actual population of flying squirrels is higher or lower than your estimate? Justify your answer.

Question 2: Do you think this is a good method for estimating the population of flying squirrels? Justify your answer.

Method 2: Mark/Recapture Experiment

Step 1: Your teacher will again randomly choose 4 regions in the habitat where you will capture flying squirrels. This time, when you trap from the four sample regions, fill in the table below. After counting all of the captured flying squirrels, record the total below. Then, mark each flying squirrel with a black marker. After successfully marking all of the flying squirrels, place them back into their habitat. Mix up the squirrels to simulate their dispersal throughout the habitat.

Sample Region	# of Flying Squirrels
1st:	
2nd:	
3rd:	
4th:	
Total Marked:	

1.) How many total flying squirrels did you trap in Step 1? _____

Step 2: Your teacher will randomly choose 4 new regions. Trap in these four regions. After trapping, do not place the flying squirrels back into the habitat. Instead, count and record the total number of flying squirrels that you trapped. Then, count and record how many of the flying squirrels were marked and unmarked.

    2.) How many total flying squirrels did you capture in Step 2? _____
             How many of the captured flying squirrels were recaptures? _____

             How many of the captured flying squirrels didn't have marks? _____

Step 3:

Most field ecologists use the generic proportion below:

$$\frac{Marked\ in\ Sample}{Total\ in\ Sample} = \frac{Marked\ in\ Population}{Total\ in\ Population}$$

For this trapping experiment, the new proportion equation is below. We can use this equation to estimate total number of flying squirrels.

$$\frac{\#\ Recaptured\ Flying\ Squirrels\ Caught\ in\ 2nd\ Trap}{Total\ \#\ of\ Flying\ Squirrels\ Caught\ in\ 2nd\ Trap} = \frac{\#\ of\ Flying\ Squirrels\ Caught\ in\ 1st\ Trap}{Estimated\ Total\ \#\ of\ Flying\ Squirrels}$$

Solve for the estimated total number of flying squirrels. Show your work. Put your data in the new proportion equation above.

Estimated Total # of Flying Squirrels = _____

Question 3: How do Method 1 and Method 2 differ?

Question 4: Which method produced the larger population number of flying squirrels? Why do you think that occurred?

Question 5: Which method gives an estimate that you think is closest to the real number of flying squirrels? Justify your answer.

Question 6: Does using math to help estimate the squirrel population make your work as an ecologist easier? Justify your answer.